REMARKS

This amendment is responsive to the Office Action of March 26, 2008. Claims 12, 21, 22, 27 and 28 have been amended herein. Claim 24 has been cancelled. Reconsideration and allowance of claims 1-23 and 25-34 are requested.

The Office Action

Claims 21 and 27-28 were objected to under 37 C.F.R. 1.75(a) as failing to conform to particularly point out and distinctly claim the subject matter which applicants regard as the invention.

Claim 22 was rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention

Claims 23-24 and 26 were rejected under 35 U.S.C. § 112, first paragraph, as failing to satisfy the written description requirement.

Claims 1-5, 7, 10-16, 19-20, 22-30 and 32-33 were rejected under 35 U.S.C. § 102(b) as being anticipated by Bani-Hashemi *et al.* (U.S. 5,690,106).

Claims 6 and 8 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Bani-Hashemi *et al.* in view of Tom *et al.* (Motion Estimation of Skeltonized Angiographic Images Using Elastic Registration, IEEE Transactions on Medical Imaging, Vol. 13, No. 3, 11/1994, page. 450-460).

Claims 9, 17-18, 21 and 31 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Bani-Hashemi *et al.* in view of Levin (U.S. 5,546,472).

Objection to Claims 21, 27 and 28 Under 37 C.F.R. 1.75(a)

Claims 21 and 27-28 have been amended to cure minor informalities. Applicants' representative thanks the Examiner for his helpful suggestions. Thus, it is respectfully requested that this objection be withdrawn with respect to **claims 21 and 27-28**.

Motion Model vs. Registration

The Examiner does not appear to understand the difference between a motion model and registering images. A motion model describes object motion, such as breathing. See, for example, page 12, line 23 – page 14, line 5 of the present application.

Bani-Hashemi *et al.* has not disclosure and does not address motion models. Rather, Bani-Hashemi *et al.* is concerned with lining up two images so they can be subtracted. The process of lining up the two images is also known as registration.

The Present Application

Some imaging modalities, like PET and SPECT, have relatively long data acquisition times as compared to basic physiological cycles such as the respiratory cycle or the cardiac cycle. Consequently, these images are motion artifacted.

Another drawback of PET or SPECT imaging is that the images are limited to images of the radio pharmaceutical. In one common PET or SPECT imaging technique, the radiopharmaceutical is carried by the blood and the image is an image of the vascular system. However, because the image is only of the vascular system without the surrounding tissue, it can be difficult to interpret and relate to the patient's anatomy.

Other imaging techniques such as CT or MRI can be used to generate anatomical images in one or more individual states of motion.

The single state CT or MR images are interpolated or extrapolated into a motion model for the range of motion through which the patient moves during the collection of the SPECT or PET data. Using the CT or MRI images and the motion model, images can be generated of any motion state within the range of motion. These images can be combined with the SPECT or PET data in any of a variety of ways.

For example, PET or SPECT projections which span only a single or small range of states of motion can be combined with projections of MRI or CT data in a similar state or small range of states to create a projection showing the patient's anatomy with the blood vessel map highlighted. These projections can then be combined into an appropriate end image.

In another example, the CT or MRI images and the motion model can be used to generate a series of images in each of the states of motion in the range of motion undergone during the acquisition of the PET or SPECT data. These images can be weighted in accordance with the amount of time which the patient spent in each state of motion during the acquisition of the PET or SPECT data and combined to generate an anatomical image with the same motion artifacts as the PET or SPECT image. The like motion artifacted anatomical image and the SPECT or PET image can then be combined.

Numerous other applications are also described in the present application.

The References of Record

Bani-Hashemi ***et al.*** is directed to a different technique which is utilized in a different way to achieve different end results. Specifically, Bani-Hashemi *et al.* is directed to a registration technique. Note, in the present application, in the discussion concerning R2 of Figure 1, before two images are combined, the two images are registered or brought into physical alignment. Bani-Hashemi *et al.* is directed to a technique for registering or bringing two images into alignment.

Bani-Hashemi *et al.* relates to angiographic imaging utilizing a C-arm x-ray source and detector. Bani-Hashemi *et al.* generates a stack of planar images using the C-arm x-ray device. If one moves the x-ray source and the x-ray detector back and forth in opposite directions along horizontal parallel lines on opposite sides of the patient, the x-ray trajectories between the x-ray source and the detector will rock about a single plane mid-way between the two. With every sampling, data from within that plane becomes reinforced while data outside that plane becomes a blur or average of radiation attenuation over different tissue types. In this way, an image of a single slice is generated. By shifting the relative vertical position of the x-ray source and detector, each slice of the stack can be generated. However, when more sophisticated mathematics are utilized, the x-ray source and detector can be moved in non-parallel lines, e.g., rocked back and forth about the pivot point of the C-arm. Moreover, using the more sophisticated math and by rebinning and reorganizing the rays of data, all of the data for generating the stack of planar images can be generated.

As can be imagined, as compared to a CT scanner, the images generated by the C-arm x-ray source are a bit crude. The data is generated over a limited arc. Moreover, the C-arm is a large, heavy structure and there is play during its movement, rendering reproducibility elusive.

On the other hand, C-arm x-ray devices are much cheaper than a CT scanner. Moreover, C-arm x-ray systems are very flexible and can be utilized for a very large number of very diverse x-ray based examinations.

Bani-Hashemi *et al.* is concerned with digital subtraction angiography. Digital subtraction angiography is often done in the patient's legs. More specifically, the C-arm assembly is moved to each of four or five stations along the legs and operated to generate a stack of images at each station.

In digital angiography, the C-arm is moved to generate two stacks of images at each station, one with contrast agent and another or mask image without the contrast agent. As can be appreciated, all of this moving from station to station and rocking the C-arm at

each station renders it highly unlikely that the mask and contrast agent images will be aligned.

Bani-Hashemi *et al.* describes a technique for registering or aligning the contrast and mask images. Specifically, Bani-Hashemi *et al.* takes a first derivative of the corresponding mask and contrast images to generate a pair of images which are merely the outlines of veins and other structures. Next, he chooses several subareas or tiles of one of the images and compares it with subareas of the other image to find the corresponding tile location and orientation. He then determines the transform, i.e., translation, in-plane rotation, and magnification needed to overlay one tile on the corresponding area of the other image. It might be noted that if the tiles are exactly aligned in both images, there would be zero translation, zero rotation, and zero magnification. Rather than determining the transform for every subregion, Bani-Hashemi *et al.* takes a plurality of subregions of each planar image, determines the transform for each of the subareas, and interpolates the transforms for areas between the actually checked subareas. Once the mask or contrast image has been transformed into registration or alignment with the other image, the two planes can be subtracted to generate an angiogram or map of the patient's blood vessels.

In brief summary, Bani-Hashemi *et al.* is directed to a technique for registering or bringing a planar contrast image and an planar mask image into alignment prior to subtracting the two images. No motion model is generated, no intermediate images are generated, and no intermediate images are combined with either the contrast or mask image.

Tom *et al.* appears to disclose an approach for estimating the motion of arteries in digital angiographic image sequences.

Levin appears to illustrate obtaining an image from an object by acquiring training signal measurements and deriving a set of basis functions that provide a convergent series expansion of the images.

The Subject Claim is not Indefinite

Claim 22 was rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. It is respectfully requested that this rejection be withdrawn for at least the following reasons. Claim 22 has been amended to recite *an ultrasound system*, rendering Examiner's rejection moot. Thus, it is respectfully requested that this rejection be withdrawn with respect to **claim 22**.

The Claims Satisfy the Written Description Requirement

In particular, **claim 23** recites *registering coordinates systems of the first and second imaging modality data acquisition systems.* The claimed subject matter is supported in the Specification at page 14, lines 18-26, which states "[r]egistration is a generally known method of equalizing co-ordinate systems between two or more images with corresponding structures; a physical correspondence of two identical objects of different contents may then also occur." A person having ordinary skill in the art could interpret the claimed subject matter when read in light of the Specification, because registration is a generally known method of bringing coordinate systems of images into alignment so that images can be combined.

Claim 24 has been cancelled, rendering Examiner's rejection moot.

With regard to claim 26, as is well-known to those of ordinary skill in the art, motion modesl are normally used to model cyclic motion, particularly cardiac and respiratory motion. The motion model describes how internal organs move between a first motion state, e.g., inhale, and a second motion stage, e.g., exhale.

The specification makes it clear that the motion model includes at least two states, e.g., inhale and exhale. Respiratory motion which is discussed in numerous examples in the specification is cyclic or periodic (page 13, line 9).

Claim 26 is supported by the Specification at page 2, lines 6-8; page 8, lines 17-28; page 11, lines. 11-33; page 12, lines 6-22; page 13, lines 6-12, etc. A cyclic frequency function can represent a state of motion function, and the state of motion function describes motion of an object. Therefore, *the sensed motion is a cyclic motion in which the object cyclically assumes each of a plurality of motion states* is supported within the Specification.

Additionally, applicants' representative reminds Examiner that the claimed subject matter need not be described *in haec verba* in the original specification in order to satisfy the written description requirement. *See* In re Wright, 866 F.2d at 425. In view of the foregoing, it is readily apparent that claimed subject matter satisfies the written description requirement under 35 U.S.C. § 112, first paragraph. Accordingly, this rejection should be withdrawn with respect to **claims 23, 24 and 26.**

<u>The Claims Distinguish Patentably</u>
<u>Over the References of Record</u>

Independent **claim 1** recites ***determining a motion model which characterizes states of motion assumed by the object*** *while moving through the states of motion.* Bani-Hashemi *et al.* fails to disclose or suggest the claimed subject matter.

Contrary to the Examiner's assertion, **W^n is <u>not</u> a motion model.** A motion model as definined in claim 1 characterizes states of motion assumed by the object. W^n describes how much two images are out of alignment. In Bani-Hashemi *et al.*, patient movement is not disclosed. Rather, Bani-Hashemi *et al.* moves the imaging apparatus between taking the contrast image and the mask image. In order to subtract the mask and contrast images (and get meaningful results), Bani-Hashemi *et al.* needs to line-up the two images.

The cited reference relates to acquiring two sets of images (a mask and contrast series) by rotational imaging of a stationary object. The mask images are subtracted from the contrast series to provide an angiogram (more specifically, depicting the blood vessels with the contrast agent). Examiner contends that Bani-Hashemi *et al.* discloses the claimed subject matter at column. 10, lines. 41-61 (*See* Office Action dated March 26, 2008, page 17). Applicants' representative avers to the contrary.

Although the cited reference appears to collect images as the c-arm moves about a patient, the cited reference does not determine a motion model from these images. At column 10, lines 41-61, the cited reference appears to disclose the use of scaling transformations to compensate for organs that move during the image gathering process. This is different than a motion model, because the scaling transformations appear to create a uniform stationary image, and are not representative of an object in motion. Therefore, the cited portion of the reference fails to disclose or suggest ***determining a motion model which characterizes states of motion assumed by the object*** *while moving through the states of motion,* as recited by independent **claim 1**.

Furthermore, Bani-Hashemi *et al.* fails to disclose or suggest ***forming an intermediate image of the object from the motion model and the second modality images****, the intermediate image representing the object as if it had moved over the range of motion over which the object moved as the first modality data was acquired,* as independent claim 1 recites. Examiner contends that the cited reference discloses an intermediate image and second modality images the "Mask Sequence" at Fig. 3, and a motion model at Fig. 4 (item 5)

(*See* Office Action dated March 26, 2008, page 17). Applicants' representative respectfully disagrees with such contention.

Figure 4 appears to disclose a flow chart of a registration technique employed by the cited reference. Item 5 relates to the transformation of data for *registration*, and is not indicative of a motion model. Rather, the interpolation allows for a revised depiction of a stationary object by using multiple data points. This is evidenced by step 4, in which the process of collecting image data is repeated to compensate for any apparent artifacts.

Furthermore, the Examiner contends that an intermediate image and second modality images are disclosed by the "Mask Sequence" at Fig. 3 (*See* Office Action dated March 26, 2008, page 17). However, the subject claim recites *forming an intermediate image of the object from the motion model and the second modality images*. Based on Examiner's citation, the intermediate image would be formed from itself and Fig. 4, Item 5. It is not possible to form an image from itself and an interpolation. Thus, the cited portions of the reference fail to disclose or suggest ***forming an intermediate image of the object from the motion model and the second modality images****, the intermediate image representing the object as if it had moved over the range of motion over which the object moved as the first modality data was acquired*, as independent claim 1 recites.

Claim 2 recites ***determining a motion model that characterizes states of motion assumed by the object***. Independent claim 3 recites a similar feature. Examiner contends that Bani-Hashemi *et al.* discloses the claimed subject matter at column 10, lines 41-61 (*See* Office Action dated March 26, 2008, page 18). Applicants' representative avers to the contrary.

The cited portions of Bani-Hashemi *et al.*, as noted *supra*, appear to disclose the use of scaling transformations, which allow the system to more accurately portray organs that move during the image gathering process. The scaling transformations appear to create a uniform stationary image, which is different than a motion model. Therefore, the cited portion of the reference fails to disclose or suggest ***determining a motion model which characterizes states of motion assumed by the object*** *while moving through the states of motion*, as recited by independent **claim 2**.

Moreover, independent claim 19 recites ***determining a motion model related to periodic motion of the object based on the second sequence of image data***. Claims 28 and 32 also recite determining a motion model and generating a motion model, respectively. The Examiner contends that Examiner contends that W^n is a motion model (*See* Office

Action dated March 26, 2008, page 10). Applicants' representative respectfully disagrees with such contention.

W^n is a transformation matrix used to complete a registration of reference points. Registration of an image represents alignment of stationary objects; thus, W^n is not a motion model, nor is the W^n transformation matrix used to compute a motion model. Therefore, Bani-Hashemi *et al.* fails to disclose or suggest ***determining a motion model related to periodic motion of the object based on the second sequence of image data***, as claimed.

Examiner contends that **claims 6 and 8** are rendered obvious over Bani-Hashemi *et al.* in combination with Tom *et al.* This rejection should be withdrawn for at least the following reasons. Claims 6 and 8 depend from claims 1 and 2, respectively, and Tom *et al.* fails to make up for the aforementioned deficiencies of Bani-Hashemi *et al.* with respect to the subject claims. Therefore, it is respectfully requested that this rejection be withdrawn.

Additionally, Examiner contends that **claims 9, 17-18, 21 and 31** are rendered obvious over Bani-Hashemi *et al.* in combination with Levin. This rejection should be withdrawn for at least the following reasons. Claims 9 and 17-18 depend from claims 1-3. Claims 21 and 31 depend from claims 19 and 28, respectively. Levin fails to make up for the aforementioned deficiencies of Bani-Hashemi *et al.* with respect to independent claims 1-3, 19 and 28. Therefore, it is respectfully requested that this rejection be withdrawn.

CONCLUSION

For the reasons set forth above, it is submitted that claims 1-23 and 25-34 (all claims) distinguish patentably over the references of record and meet all statutory requirements. An early allowance of all claims is requested.

In the event the Examiner considers personal contact advantageous to the disposition of this case, he is requested to telephone Thomas E. Kocovsky, Jr. at (216) 861-5582.

Respectfully submitted,

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